

World Pipelines asked a number of companies to discuss some issues regarding pigging for oil and gas midstream pipelines.

Those asked were:




 **ANDY BAIN**, Chief Operating Officer,
NDT Global


Bain has recently celebrated his 25th anniversary in the ILLI industry. Bain entered into the ILLI industry after serving in the British Royal Navy for 10 years. Bain began working in the sector with British Gas, working in all facets of ILLI, from field operations, project and operations management, to developing and leading new product development. While working as an ILLI consultant, he worked with major operators in oil and gas. During this period, a project of particular significance saw Bain help deliver inspection solutions for deep subsea systems. He joined NDT Global in 2016 and is responsible for the group's business operations globally.

 **SEAN TUCKER**, Subsea Pipeline and Pigging Engineer,
Jee Ltd

Tucker joined Jee Ltd in 2012 after graduating from Brunel University in London with a MEng in Civil Engineering with Sustainability. Since then, he has been heavily involved in pigging projects in the North Sea, Angola and Trinidad and Tobago, providing feasibility studies, pipeline piggability assessments and assurance documentation, tool selection, stuck pig guidance and contingency plans, and onshore support and onsite management (focal point) of offshore pigging and plugging operations. Tucker's experience includes challenging and complex operations using tethered crawlers, bidirectional inspection tools and pipeline isolation tools in addition to more conventional pigging operations.

 **DAN REVELLE**, Vice President, Western Hemisphere Inspection,
Quest Integrity

Revelle oversees the inspection and condition assessment of pipelines, process piping and fired heaters for Quest Integrity in North and South America. Revelle has worked with Quest Integrity and its predecessor companies since 1996, and was one of the main developers of Quest Integrity's LifeQuest Pipeline software. He has worked on creating advanced engineering solutions from laser and ultrasonic inspection data, as well as several other specialty engineering software programmes. Revelle has a Bachelor's Degree in Physics from Carleton College, a Master's in Aerospace Engineering from the University of Colorado and extensive experience in computational mechanics.

 **KRUNAL SHAH**, Head of Engineering,
FALGUNI SOOD, Metallurgist,
VKVC LLP

Shah did his undergraduate study in Production Engineering. He has been working in the pipeline industry for the past seven years. He has worked on various projects with Engineers India Limited, PDO, ONGC, Qatar Petroleum, Shell, Petronas, KOC, IOCL, GAIL and more. Sood completed her Masters in Material Science & Engineering from SUNY Binghamton (USA), with focus on joining techniques in microelectronics. She currently works with the material selection, processing and testing department for pigs at VKVC and has been part of multiple pigging operations.

Read on to hear what they have to say...

PIGGING Q&A

Q Pigs as part of integrity management systems



ANDY BAIN, NDT Global

Inline inspection (ILI) tools play a fundamental role in pipeline asset integrity management programmes. These tools are one of the very select methods that provide operators with the full, in-depth range of measured data regarding their assets. In contrast, other methods generate information based on samples, predictions and models. With the multitude of technologies available with ILI, operators are in a position to get a clear picture on potential threats posed to their asset, and they can then optimise their integrity management programme accordingly.



SEAN TUCKER, Jee Ltd

Pigging is an important part of effective integrity management and is present at many stages of the integrity management cycle.

Upon or before pipeline commissioning, a baseline ILI is good practice to understand the condition of the pipeline prior to operation, allowing subsequent inspection results to be compared against the initial condition to assess defect growth over time. In the absence of a baseline ILI, it is sometimes difficult to deduce whether a defect is as a result of manufacturing or due to corrosion, and can result in non-conservative defect growth assessments. Regular ILI campaigns also allow for corrosion rates to be established for known defects, and enable more accurate fitness for purpose studies to be carried out.

Operational pigging throughout the lifecycle of a pipeline is also crucial to prevent the accumulation of debris, which can provide a favourable environment for corrosion mechanisms such as microbial induced corrosion. For gas lines, regular sphering prevents any water dropout from pooling in low points by sweeping liquid from the line.



KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

Pigs are a universal solution used by the oil and gas industry as part of their pipeline integrity management system. Pipeline failure could cause operators losses worth millions of dollars in terms of man hours, equipment and safety.

Intelligent pigs are used to gather data from an existing pipeline regarding their physical parameters. This data is interpreted to estimate the current state of the pipeline. Depending on the results, the pipeline operator outlines a pipeline maintenance and repair programme.

It is essential to have a pigging programme outlined. Depending on the pipeline media, intelligent pigging should be performed not less than once a year. For crude oil pipelines, depending on debris, wax and sand, regular weekly cleaning should be performed. For gas pipelines, depending on whether it is dry gas or contains liquids, pigging can be performed. Wet gas pipelines may have

hold up in low lying regions, which would be required to be removed when detected. A corrosion expert should be contacted to determine the risk of corrosion to a pipeline, and a corrosion pigging programme should be put in place depending on the results.

Waxy crude oil pipelines have solid wax particles precipitated and retained in the interior walls. Recently, a crude oil pipeline exhibited severe pressure build-up due to such wax deposits. This build effectively reduced the inner diameter and, hence, the throughput. VKVC used its foam pigs with solvent slugs in between to clean this pipeline. Successful pigging resulted in wax removal along with the pig.



Q Performing pipeline maintenance and repair with pigs



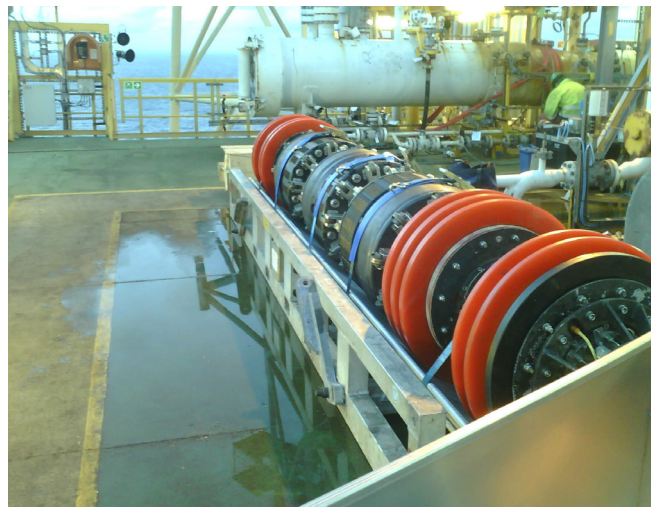
ANDY BAIN, NDT Global

With this in-depth information, operators can balance the repair and maintenance cost and risk in the management of their pipeline integrity. Multiple aspects of real and accurate data provided by NDT Global that pertains to a specific location in a line allows operators to have a clear plan of action, particularly in relation to exterior influences, i.e. land permits, construction etc., in a less intrusive manner.



SEAN TUCKER, Jee Ltd

Specialised isolation plugs – typically multi-module tools consisting of forward and rear pigging modules, and a number of isolation plug modules – can be used to isolate an area of pipework to enable maintenance and repair to be carried out safely. These tools remove the requirement to depressurise the pipeline down to the nearest permanent isolation point, which could be several kilometres away, keeping platform downtime to a minimum. These tools commonly utilise hydraulics and differential



Jee Ltd: 34 in. TDW SmartPlug® prior to loading (operation project managed by Jee).

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Jee Ltd: Lifting operations for 34 in. TDW SmartPlug prior to loading (operation project managed by Jee).

pressure to compress the modules, forcing slips and seals onto the pipe wall to hold the tool in place and provide the leak tight seal.

Sealing or barrier pigs can be used for a similar purpose, though instead of resisting high pressures they need only provide a barrier to prevent the migration of hydrocarbons toward the jobsite after the pipeline has been depressurised. These are typically used in liquid or multiphase lines where depressurisation is less time consuming. If it is not possible to completely flatten the pipeline, then high friction pigs can be used to hold relatively low pressures. For higher pressures, approximately >10 bar, isolation plugs will typically be required.

For isolation plugs, it is important to consider the stresses that are applied to the pipe wall in order to avoid plastic deformation. Jee's extensive pigging and plugging experience has enabled us to develop bespoke assurance processes and documentation, which for plugs includes checks on pipe stresses in addition to the typical piggability reviews.

A KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

Pipelines are expensive, so integrity is a major concern for all pipeline operators. Pigs are bodies moving in a pipeline, using the product flow or air/nitrogen and performing a specific function. Operators use pigs to detect corrosion, degradation and mechanical damage. The reason pigging is so popular is because pipelines do not need to be emptied during pigging operations, thus avoiding downtime costs. When it comes to pigs, one solution does not fit all. Operators have choices from over hundreds of pig types, so selection needs to be careful as the wrong one may do more harm than good.

Q Approach to hazards and risks when pigging

A ANDY BAIN, NDT Global

An ILI is a well thought out and executed process, a lifecycle if you will. It is imperative, therefore, that

vendors are fully aware of the potential hazards that arise when introducing high tech equipment into a somewhat foreign environment. NDT Global's advance planning process associated with such environments – working with hydrocarbons, high pressure levels, chance of irregularities – enhances our close working relationship with operators.

A SEAN TUCKER, Jee Ltd

Each pigging operation, regardless of complexity, should be subject to suitable risk assessments and reviews (e.g. HAZID/HAZOP) to identify potential hazards and to ensure that appropriate mitigations are in place prior to commencement. Pigging by its nature is one of the most risky operations a pipeline can face, with both health, safety and environment (HSE) risks (breaking containment to load/unload pigs, handling of pipeline debris) and commercial risk (stuck pigs).

Jee's technical assurance process, which is continually updated with lessons learned from over 10 years' involvement in the development and implementation of cleaning, ILI and plugging operations, ensures that best practice is followed and issues are not repeated. Our cross-operator experience means that knowledge and experience is shared throughout the industry.

Stuck pig contingency plans should also be in place prior to the operation, to ensure that the appropriate actions are taken in the initial moments after an indication of a potential stalled pig has arisen to prevent the situation worsening. Jee's stuck pig guidance documentation is based on tried and tested methods and is tailored specifically for each pigging campaign, as the type of pigs used, the process conditions and geometry can affect the options available.

A KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

A pigging operation success can never be guaranteed. There are numerous possibilities where things may go wrong resulting in failure. Most accidents take place while launching and receiving pigs. So, it is essential to have predefined procedure steps that are to be followed. An interlock system between the quick opening closure (QOC) and valves is required. This should be a single process with ordered actions such that the QOC remains locked even if a single step is out of order. The main philosophy behind this system is to make sure that the pig trap is never opened while still under pressure. The personnel performing the pigging should ensure that the launcher/receiver is fully drained before the QOC is opened. This draining removes the pressure necessary to initiate pig movement. Sloping the barrel towards the outlet drains during design and manufacturing is also required to ensure fluid removal. Speed excursions occurring in gas pipelines might cause the high velocity pig to collide with the QOC when close to the receiving end of the pipeline. In a very unlikely and catastrophic event, if the QOC locking mechanism is not working, the pig might collide with it and escape. To avoid such incidents, it is important to have

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sufficient line pressure, proper flow and a safe locking mechanism in place. VKVC believes in multiple level checks, rigorous supervision, strict quality control procedures and meticulous planning to make sure pigging operations performed are safe for the personnel and equipment. VKVC performed pigging on a crude oil pipeline in western India. The operation was to remove a previously stuck pig by another supplier. The first stuck pig was successfully removed, while the second pig got stuck near the receiver end. The team was able to get it out by applying reverse back pressure through the bypass filter. This operation was done for a pipeline length of 287 km within 24 hrs.

Q Technological developments in intelligent pigging

A ANDY BAIN, NDT Global

We work internally and with external sources to develop and execute a strategy that fits with where the industry currently sits and where it is moving. One example is the demand for more accuracy and better feature discrimination, which is paramount to integrity management. With this in mind, we have recently introduced technological advancements that underline NDT Global's commitment to push the boundaries in what technological improvements can achieve.

A DAN REVELLE, Quest Integrity

Modern ILI technology has been revolutionised in the past few decades, making the concept of 'unpiggable' pipelines a thing of the past. Tools today can be light weight, bidirectional and configured to navigate and detect unknown pipeline conditions in pipelines as small as 2 in. dia. By utilising temporary launch facilities, even pigging valves can be used to access a pipeline in-service. If a foam pig can be run in the line, then so can an inspection pig.

Next generation inspection technologies allow for very high resolution profiling of the pipeline, with direct measurement of both wall thickness and geometry defects with integrated ultrasonic signal processing. Overlapping sensors on the inspection pigs provide a detailed picture of any pipeline anomalies, as well as redundancy to improve first run success.

Fixed standoff ultrasonic sensors allow for detailed profiling of corrosion under insulation, at pipe supports and cased crossings. Improved navigation capabilities allow for confident inspection of over-water wharf lines and offshore pipelines not only with confidence that the tools will successfully navigate the pipeline every time, but also with minimal health, safety and environment risks, minimal disruption to standard pipeline operations and minimal equipment footprint.

Q Safety and durability of pipeline pigging equipment

A ANDY BAIN, NDT Global

Upholding safety standards is paramount to the industry in which we operate. We work in potentially hazardous atmospheres and in an industry driven by expediency and on-time delivery. Our range of ILI pigs rely on their durability, reliability and adaptability to the environment and application in which they will run. All of the technology we employ complies with regulatory and industry standards.

A KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

The pipeline's condition is a major factor in deciding how safe pipeline pigging equipment is. This is especially true for gas pipelines.

In liquid lines the product maintains the speed of the pigs being used. The liquid acts as a lubricant, helping maintain optimum flow conditions for the pig and preventing the pig from getting stuck. In gas pipelines, however, if a pig gets stuck the results can be drastically different. Consider the following: a pig has become stuck at a certain location due to a weld bead. Now, due to the compressible nature of gas, the pressure behind the pig can start to increase. At a certain pressure the pig will overcome the obstacle and now move with a much higher velocity. At such speeds, a cleaning pig will not be able to clean the line properly and an intelligent pig will not collect data efficiently.

All equipment has a certain defined useful life and the case is no different for pigging equipment. With proper care and handling, the equipment life can be increased considerably. Certain components are meant to be used only once, such as a foam pig. Foam pigs absorb the liquid while in the pipeline and cannot be



NDT Global: High resolution ultrasonic inspection tools identify the true state of corrosion in a pipeline.

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used for pigging again. Also, pig components such as seals, discs, spacers, brushes and cups can be used effectively for a limited period. The operator should always have extra spares in stock for use.

Q Long range pigging



ANDY BAIN, NDT Global

When conducting an ILI, we inspect the pipe wall millimetre by millimetre. Current highest resolution tools have sensors every 0.75 mm (0.03 in.) in the axial direction and every 4 mm (0.16 in.) in the circumferential direction, so we run a very efficient inspection system while collecting the data. Our pigging tools maintain this coverage over the long distances they travel, whereas an adoption of such a level of inspection does not occur during every phase of the construction or installation of a pipeline.



SEAN TUCKER, Jee Ltd

Pigging long pipelines can be a challenge, namely due to wear on sealing elements and battery life, which need to be considered in the design and selection of the appropriate pigs. Increasing the flexibility of sealing discs by introducing notches is an option to reduce wear, but requires careful review of the flow bypass as this may introduce a risk of pig stall.

For inspection tools, where battery life may be a concern and there are limitations on tool length (e.g. because of receiver dimensions) delayed activation systems can be introduced to ensure a particular area of focus is inspected. These systems commonly involve activation of the ILI tool only after a set distance has been recorded on the odometers or by using external transmitters, which, when passed, send a signal turning the tool from a 'listening' to fully powered on state.

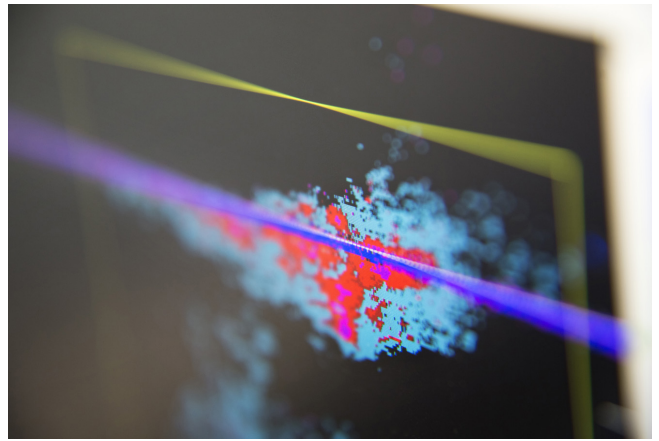
Long pipelines can also pose an issue with the amount of debris that can be contained in the receiver. Therefore, cleaning pigs should be optimised to limit the amount that can be removed in a single pass to prevent blockage.

Q Pigging valves



ANDY BAIN, NDT Global

Valves represent a significant cost in comparison to lines, so it is of the utmost importance that vendors avoid causing damages when conducting an ILI. Sometimes, occasions arise where a pigging valve has a different nominal internal diameter; this presents a challenge and may make the line unpiggable. We have the capability to accommodate a limited level of differing internal diameters. However, the identification and selection of valves plays an integral role in overall pipeline integrity. Should the valve internal diameters differ



NDT Global: Collected data delivers accurate and up to date insight into the structural integrity of your pipeline.

substantially this could compromise the level of accuracy obtained and result in a more conservative assessment.



SEAN TUCKER, Jee Ltd

Pigging valves (ball valves with an opening on the side to facilitate loading and unloading of single module pigs) enable a quick and effective method of launching and receiving single module operational cleaning pigs. They also feature mesh stops at the end to prevent the pig from travelling beyond the valve on receipt.

Jee has provided technical assurance to an inspection campaign where such valves were used to launch foam and small proving pigs. The pigs were fitted with gauge plates to confirm the condition of the bore and cleanliness level prior to connecting a temporary launcher to launch more aggressive cleaning pigs and the inspection tool. Launching proving pigs in this manner enables critical restrictions to be identified early on in the campaign, and allows a decision to continue to be made before investing time in installing temporary equipment.

Jee also provided conceptual design work for a floating storage and offloading vessel where pigging was only expected to be required during commissioning activities. To remove the need to retain space in the already congested turret for temporary commissioning pig traps, the use of pigging valves in place of traditional valves was proposed to allow launching and receiving of commissioning pigs, whilst the valves retained a non-pigging purpose after commissioning.

There are some single module inspection tools on the market that can be launched via these pigging valves, though they are limited to shorter pipelines because of limitations on battery life. Use of these valves is also typically limited to relatively clean lines as there is little space to retain debris in the valve; excessive debris may prevent the pig from entering the valve on receipt.



DAN REVELLE, Quest Integrity

Pigging valves allow for the launching and receiving of pigs into a pipeline, with minimal disruption of



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the pipeline operations. Originally designed to help simplify maintenance pigging and cleaning operations, technologies now exist that allow for high resolution inspection using these same pigging valves.

By allowing for regular cleaning pigs to be run, pigging valves help to ensure reliable operation and maximum throughput on pipelines. These regular cleaning programs and access points also allow any easy access point for regular inspection. By running high resolution inspection tools, an operator can easily monitor corrosion rates along the entire length of a pipeline, allowing for early action on any integrity threats and scoring the effectiveness of corrosion inhibitor programmes.

A KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

Valves can be a major problem during pigging. Ideally, fullbore ball valves or through conduit gate valves having a diameter equal to the pipeline should be used when the pipeline is being constructed to ensure piggability. Even when the correct valves are used, if the valve is not opened properly the pig can get stuck and cause damage to both the valve and the pig. So, it becomes important during pigging to check if the valves are in the correct open



VKVC LLP: VKVC foam pigs to treat wax build up in crude oil pipelines.



VKVC LLP: VKVC foam pig near the receiver end after successful removal of the stuck pig.

position before the pig reaches the valve. When valves with smaller diameters are used, the pig selection has to be done carefully. In this case, the design of the pig may not be as efficient for its functional purpose, and so the pigging operation might need to be suitably customised.

Q Launchers and receiver: design specifications, pressure and flow

A ANDY BAIN, NDT Global

High accuracy is dependent on a high volume of data points. Optimising the flow conditions to achieve this whilst considering the operator's commercial constraints is a critical step in inspection planning. The investment into suitable launchers and receivers avoids further unnecessary compromises in acquiring the highest quality data.

A SEAN TUCKER, Jee Ltd

When designing pig launchers and receivers, it is important to ensure that they are designed to the same code as the pipeline and have an equal or greater design pressure.

Launchers should have the barrels sized accordingly to ensure that the longest tool to be used can fit in the trap and that only the front drive seals need be pushed into the minor barrel, in order to minimise the loading force required. Receivers should be sized such that the minor barrel is long enough to ensure that the longest tools can drive fully clear of isolation valves prior to losing seal in the reducer/major barrel.

In terms of flow, the outlet on receivers should be as close to the door as practical, to ensure that the tool retains drive past the isolation valve and can be recovered easily from the trap. Conversely, on launchers, the kicker line should be positioned as close to the reducer as possible to ensure drive is provided from the forward modules, keeping couplings on multi-module tools in tension. Balance lines should always be included to allow equalisation across the pig when pressurising to prevent movement of the pig in the trap prior to launch. Jee can perform third party verification of pig trap designs to ensure that they are optimised for the tools to be used and review existing traps for suitability.

A KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

As the name suggests, launchers and receivers (also known as pig traps) are used to launch or receive pigs to, or from, a pipeline. Each pipeline is different, so the design requirements for pig traps would be dependent on the specific location and service conditions. Pigs traps consist mainly of a pig barrel, nozzles, QOC, reducer and a pipe section equal to the pipe inner diameter (neck pipe). An optional tray or basket is provided for easier handling of pigs. The top priority for any launcher/receiver

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designed by VKVC is safety to the personnel and equipment. Critical aspects of trap design to ensure safety are the length, sealing capability of the QOC and arrangement of components on the trap. The pig traps should be designed with the smooth passage of pigs kept in mind; transitions in the internal diameter due to changing wall thicknesses should be tapered, internal surfaces should be smooth and the length should be enough to contain the longest pig that the operator would want to use with certain margin. Even if all customer and design requirements are met, VKVC always suggests to hydrostatically test the trap before installation to add another safety step.

Q Pigging as a flow assurance solution



ANDY BAIN, NDT Global

The results of an ILI campaign can provide the operator with a clear representation of the efficiency of their maintenance programmes. This can affect not only the integrity (cathodic protection), but also the intended flow regime of the pipeline system, build-up of debris or 'holidays' in the application of inhibitors (water, oxygen and corrosion).



SEAN TUCKER, Jee Ltd

Operational pigging plays an important role in flow assurance by preventing debris from accumulating, which, over time, can cause a restriction to the flow and reduce pipeline throughput. Pigging should be considered during the design of a pipeline system and a cleaning study should be performed to assess the volume and type of debris expected throughout the lifecycle. From there, an operational cleaning strategy can be put in place to regularly sweep debris, such as wax from the line, to reduce the risk of blockage and associated reduction in throughput.



KRUNAL SHAH & FALGUNI SOOD, VKVC LLP

The efficiency of a pipeline can be analysed by the throughput obtained against the throughput required. Even though a pipeline is the most economical way to transport fluid from one location to another, they can become cost-ineffective by loss of throughput. Operational pigging can offer an economical solution. Pigs can remove any unwanted substances before they create a problem big enough to cause a pipeline shutdown. These unwanted materials can create corrosion cells in the future. Liquids can get held up in low lying regions of the pipe. The amount might be small when considered over a short time, but over the years this material wastage accumulates and causes loss of extensive valuable sellable product. Pigs provide a tight fit inside the pipe and can prevent wastage of the pipe media. What might seem like a cost now, saves much more in the long run. 